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F.M. 98

September 1952

NOV [illegible] 1952
U.S. DEPARTMENT OF [illegible]

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UNITED STATES DEPARTMENT OF AGRICULTURE

Bureau of Agricultural Economics

ECONOMIC CONSIDERATIONS IN USE OF UREA FOR FEEDING BEEF AND DAIRY CATTLE

Washington, D. C.

ECONOMIC CONSIDERATIONS IN USE OF UREA FOR FEEDING BEEF AND DAIRY CATTLE

By Ralph D. Jennings, Agricultural Economist

In recent years, interest in the possibilities of the use of urea in feeding livestock has been considerable. This report was prepared to bring out some of the economic considerations involved. 1/ Urea is a nitrogen compound that is converted in the rumen of cattle, sheep, and goats into the protein of living microorganisms. 2/ As the microorganisms die, the protein is available for the ruminant to use for its own body. Urea is manufactured and used in the making of plastics, fertilizer, and as a feed supplement. One pound of urea contains as much nitrogen as 6.4 pounds of average cottonseed or soybean meal; therefore, one pound of urea will replace the nitrogen in 6 to 7 pounds of oil meal. However, urea contains no feed energy, so a quantity of grain equal in energy to the oil meal replaced must be fed with it. The conventional expression for this substitution is that 1 pound of urea plus 6 pounds of grain are required to replace 7 pounds of 41-percent oil meal. 3/ Several thousand tons of urea are now manufactured annually and a considerable increase in output is anticipated during the next few years. It is the purpose here to review some of the experimental work and, in view of price relations between grain and oilseed meals in different parts of the country, to explore the place that urea may have as a feed supplement.

FATTENING BEEF CATTLE

In fattening beef cattle in drylot, experiments at the Iowa Agricultural Experiment Station show that feeding 0.1 pound of urea a day was not profitable even if the price of the soybean meal replaced was very high. One pound of urea, plus 7 to 8 pounds of corn, plus a little hay, replaced only 4 or 5 pounds of soybean meal. In one case, the ration was corn, soybean meal, and hay and half of the soybean meal was replaced by 0.1 pound of urea. The other experiment was similar except that 1 pound of molasses took the place of a part of the corn. The daily gains on the two lots without urea were 2.2 and 2.0 pounds a day and on those fed urea 2.1 and 1.8 pounds. When the amount of urea was increased to 0.2 pound per day in this experiment, replacing all of the soybean meal, the daily gain equaled or exceeded the lots without urea and 1 pound of urea plus 1 to 5 pounds of corn replaced 6 to 7 pounds of soybean meal. In the latter experiment, the feeding of urea would have been profitable with urea at 6 cents a pound, corn at 2 cents, and soybean meal at 2 cents or more. In an experiment at the Iowa station in which corn silage, linseed meal, and alfalfa were the fattening ration, urea was fed at the rate of 0.2 pound a day and the linseed meal was reduced from 2.5 to 1 pound a day. The daily gain in the two lots was 2.18 and 2.04 pounds, the latter

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1/ The experimental data used were selected with the advice of N. R. Ellis of the Animal Husbandry Division, Bureau of Animal Industry and L. A. Moore, Division of Nutrition and Physiology, Bureau of Dairy Industry.

2/ Bibliography on Utilization of Urea, Ammonia and Related Non Protein Nitrogen Compounds in Animal Feeding. AHD No. 143, N. R. Ellis Bureau of Animal Industry, USDA.

3/ The Use of Urea as a Feedstuff, AHD No. 142, N. R. Ellis, Bureau of Animal Industry, L. A. Moore, Bureau of Dairy Industry, USDA.

being the urea-fed lot. In this experiment, 1 pound of urea plus 16 pounds of silage replaced 6.6 pounds of linseed meal.

The effect of urea on the cost of a fattening ration in this experiment is shown in table 1. Ten dollars a ton for the silage and $22.50 a ton for alfalfa hay were used in the cost calculations, with varying prices for linseed meal. These prices are about in line with corn at 2 1/2 cents a pound, which is near the average price in the Corn Belt in recent years. Use of urea in place of linseed meal resulted in a lower feed cost with almost any conceivable price for linseed meal. With linseed meal at 4 cents a pound the ration with urea would cost 7 percent less than the linseed meal ration, not taking into account any additional cost of preparing the ration containing urea.

Judging from these few experiments, it would seem that urea can replace enough oil meal in fattening cattle in the Corn Belt to be profitable under almost any foreseeable relative prices of oil meal and corn. This assumes that the urea can be mixed uniformly into the ration without any substantial increase in cost, so that there is no danger that an animal will obtain enough of the urea at one time to be toxic. This would involve some additional cost when a ration containing shelled corn, oil meal, and hay is fed. Probably a part of the corn would have to be ground and mixed with the urea to insure a safe mixture. If the farm had feed-mixing facilities or if custom-mixing facilities were used, the additional cost would probably be small. Considerable initial cost might be involved if mixing facilities were not already used. In no case should urea be used unless it is thoroughly mixed with at least a part of the daily feed. Probably a mixture of 1 pound of urea to 9 pounds of grain would be sufficient dilution. Then, if one wished to feed one-fifth of a pound of urea a day, 1 pound of the mixture could be fed twice a day along with the shelled corn or other feed. Urea can also be mixed with molasses and the mixture poured on the other feeds after the grain or other feed is put in the feed bunks.

In Florida, two lots of cattle were fed a ration of citrus molasses, citrus pulp, cottonseed meal, and hay, with one lot being fed urea. They made average daily gains of 2.3 and 2.2 pounds. One pound of urea plus 6 to 7 pounds of citrus pulp replaced 6.3 pounds of cottonseed meal. Two other lots of cattle on pasture were fed citrus molasses and cottonseed meal. One lot got urea but no cottonseed meal. The daily gains of the lot with no urea in the ration were 1.68 pounds. Gains for the other were 1.59. One pound of urea plus 4 pounds of citrus pulp and 2 pounds of citrus molasses saved 4.8 pounds of cottonseed meal. With these relationships, the feeding of urea in the drylot would probably be profitable with average prices for citrus pulp and cottonseed meal.

In four Louisiana trials, cattle were fed about 10 pounds of corn or corn and molasses, cottonseed meal, and hay. Urea was substituted for part or all of the cottonseed meal in two trials. More than half a pound of urea was fed per head daily. The cattle without urea averaged 1.6 and 1.7 pounds gain per head daily and those with urea, 1.4 pounds. The costs of gain were high in these trials (using the same prices as in other stations) and the cost of gain of cattle fed urea was higher than those not fed urea. Adding urea in these trials did not

Table 1.- Feed cost of fattening cattle on silage and linseed meal compared with urea, silage, and linseed meal, with different prices for linseed meal 1/

Feeds	Feed per 100 pounds gain		Assumed price per pound	Cost of 100 pounds gain with assumed prices for hay and silage when the price of linseed meal is:									
	With oil-meal	With urea		2.5 ¢		3 ¢		3½ ¢		4¢		6¢	
				Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea
	Pounds	Pounds	Cents	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Corn silage	2,110	2,270	.50	10.55	11.35	10.55	11.35	10.55	11.35	10.55	11.35	10.55	11.35
Linseed meal	115	49	--	2.87	1.22	3.45	1.47	4.02	1.71	4.60	1.96	6.90	2.94
Urea		10	6.0		.60		.60		.60		.60		.60
Alfalfa hay	115	122	1.12	1.29	1.37	1.29	1.37	1.29	1.37	1.29	1.37	1.29	1.37
Mineral	3	3	5.0	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15
Salt	2	2	1.5	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
Total cost				14.89	14.72	15.47	14.97	16.04	15.21	16.62	15.46	18.92	16.44
Cost of ration containing urea compared with ration containing linseed meal as 100 percent				100	99	100	97	100	95	100	93	100	87

1/ From mimeographed report AH 173, Department of Animal Husbandry, Iowa State College, Ames, Iowa, 1949. The average daily gain on these two lots was 2.18 pounds and 2.04 pounds, respectively. Prices used for silage and hay are in line with those for corn at $1.40 a bushel or 2½ cents a pound. The price of urea was assumed to be 6 cents a pound.

pay, as only 4 or 5 pounds of cottonseed meal were saved by each pound of urea plus 6 to 8 pounds of corn, or the equivalent in other feeds. Perhaps too large an amount of urea was used.

USE OF UREA IN GROWING OR WINTERING CATTLE

Large quantities of corncobs are wasted in the Corn Belt. In recent years considerable work has been done on feeding cobs to cattle. In three trials in Iowa, about 12 to 14 pounds of cobs a day were fed with 2 to 5 pounds of corn or molasses, 2 1/2 pounds of alfalfa hay, and with varying amounts of urea and soybean meal. The average daily gains of about 1.6 pounds were good, considering the amount of grain fed. They were somewhat less than are normally expected in cattle being grain-fattened for market, but more than for cattle being wintered. All lots were fed urea so there is no comparison of a lot without urea. The cob rations produced much slower and somewhat more costly gains than did heavy silage fattening rations, either with or without urea.

The station at Purdue has reported trials of similar rations, using corncobs, soybean meal, molasses feed, and urea. The intake of carbohydrate feeds was less and the daily gains were also less, averaging about 1 1/4 pounds. The principal carbohydrate feed was a commercially mixed molasses feed. When large amounts of this feed were used, the gains were more expensive than those in the Iowa trials. In the Purdue trials, 1 pound of urea plus about 4 pounds of the commercial molasses feed replaced 7 or 8 pounds of soybean meal. The cost of the commercial molasses feed was so high that it would not have been profitable to use urea in place of oilmeal, except when the price of soybean meal was very high. Probably some less costly feed would have done as well and would have made the use of urea profitable.

Large quantities of corn stover, straw, cobs, and poor-quality hay produced in this country contribute very little to livestock production, chiefly because they are high in fiber and difficult to digest thoroughly. Thorough digestion of these coarse roughages is promoted when high-protein supplements are added or when urea is fed along with a relatively small quantity of grain or molasses. Bacteria in the digestive tract do the work, but they must be supplied with sufficient energy. The trials with corncobs illustrate what can be done along this line in wintering rations for cattle. This is probably one of the most important prospective uses of urea.

Cost of a wintering ration for cattle consisting of corncobs, soybean meal, and molasses feed, compared with a similar ration containing urea, is given in table 2. Cattle wintered on mixed hay alone gained only about 0.9 pound per head per day and used 2,200 pounds of hay to make 100 pounds gain. The corncob ration at the assumed prices cost about $13.00 per 100-pounds gain while the hay ration at average prices for hay ($22.50 a ton) would have cost $24.75 for 100-pounds gain. The corncob ration (with corncobs charged at $10.00 a ton) with either the soybean meal or urea was much cheaper than using hay alone. In this experiment, the urea ration cost more than the soybean ration when the price of soybean meal was less than 3 1/2 cents a pound and

Table 2.- Feed cost of wintering cattle on corncobs with soybean meal and molasses feed compared with urea, molasses feed, and corn with different prices for soybean meal 1/

Feeds	Feed per 100 pounds gain		Assumed price per pound	Cost of 100 pounds gain with assumed prices for carbohydrate feeds when the price of soybean meal is:									
				2.5 cents		3 cents		3½ cents		4 cents		6 cents	
	With oil-meal	With urea		Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea	Oil-meal	Urea
	Pounds	Pounds	Cents	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Corncobs	1,130	1,132	½	5.65	5.66	5.65	5.66	5.65	5.66	5.65	5.66	5.65	5.66
Soybean meal	174	109	---	4.35	2.72	5.22	3.27	6.09	3.81	6.96	4.36	10.44	6.54
Corn		66	2½		1.65		1.65		1.65		1.65		1.65
Molasses feed	77	74	3	2.31	2.34	2.31	2.34	2.31	2.34	2.31	2.34	2.31	2.34
Urea		9.4	6	--	.56	--	.56	--	.56	--	.56	--	.56
Bonemeal	14	14	5	.70	.70	.70	.70	.70	.70	.70	.70	.70	.70
Salt	5	5	1½	.07	.07	.07	.07	.07	.07	.07	.07	.07	.07
Total				13.08	13.70	13.95	14.25	14.82	14.79	15.69	15.34	19.17	17.52
Cost of ration containing urea compared with ration containing soybean meal as 100 percent				100	105	100	102	100	100	100	98	100	91

1/ From mimeographed report No. AH 48, Department of Animal Husbandry, Purdue University, Lafayette, Indiana, April 21, 1950. The average daily gain on these two lots was 1.29 pounds and 1.28 pounds, respectively. The price assumed for corn was 2½ cents a pound and for other feeds in line with corn. The price of urea was assumed to be 6 cents a pound.

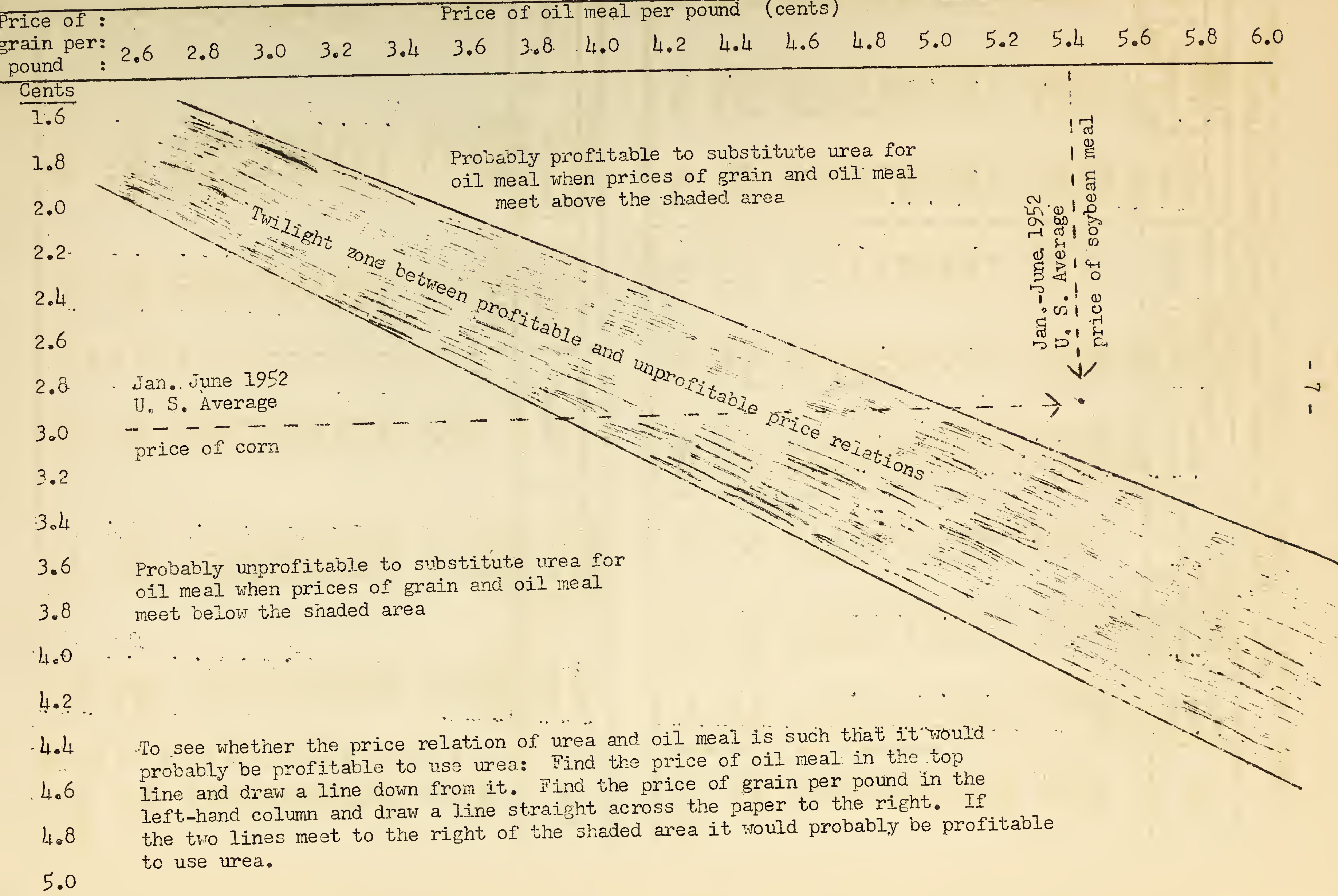
that of corn 2 1/2 cents a pound. The saving in using urea was small even when soybean meal was high in price compared to corn. In this experiment 1 pound of urea plus 7 pounds of corn replaced 7 pounds of soybean meal. The main point to this experiment is that either soybean meal or urea can be used with corncobs when properly supplemented with minerals and a molasses feed to give a low-cost wintering ration. Experiments are needed with other feeds such as cornstalks, straw, and low-quality hay.

In many range areas, the supplemental feeding of 1 to 2 pounds of cottonseed meal or soybean meal per day to cattle during a part of the winter is common practice. A mixture of urea, molasses, and ground grain in pellet form has been used effectively in Oklahoma experiments. Pellets of this kind can also be spread over the grain or other feed in feedlots to distribute the urea evenly.

Urea contains no feed nutrients in itself other than nitrogen. Thus, when it replaces a pound of oil meal in the ration, additional grain must be fed to replace the energy in the oil meal. The general assumption is that 1 pound of urea plus 6 pounds of corn or the equivalent, will replace about 7 pounds of oil meal. However, there is considerable variation from this formula in different experiments. In the Corn Belt, the 15-year average price of corn is about 2 cents a pound and that of soybean meal about 3.1 cents. If it is assumed that the price of urea is 6 cents a pound, then the value of the pound of urea and 6 pounds of corn at average prices would be 18 cents. Eighteen cents divided by 7 pounds of oil meal saved gives 2.6 cents as the price for oil meal at which it would just break even, assuming that no other costs are involved. Figure 1 shows how to tell when it is profitable to substitute urea for oil meal in cattle rations. In these calculations it is assumed that 1 pound of urea plus 6 pounds of grain will replace 7 pounds of oil meal. It is also assumed that urea costs 6 cents a pound. The shaded zone in figure 1 shows where the cost of the urea ration would be from 95 to 100 percent of the oil meal ration. It is assumed that it would take about a 5 percent difference in cost before farmers or feed mixers would shift to urea. In the first half of 1952, it was profitable to use urea using the United States average prices of corn and soybean meal (fig. 1).

The relative prices of feed grains and oil meals vary from time to time. In 1947, for instance, corn in Illinois averaged about 4.0 cents a pound, while soybean meal was about 4.6 cents a pound (table 3)(fig. 2). There would be little incentive to use urea to replace oil meal in such a year; however, in the next year, corn was 2.3 cents a pound while soybean meal was 4.9 cents a pound. Prices also vary regionally. In Alabama, for instance, cottonseed meal averages only about 23 percent higher in price per pound than corn, but it averages 60 percent higher in Illinois. In 3 of the last 15 years, the price of cottonseed meal has averaged as low or lower than that of corn. In only one year has it averaged more than 1.6 times the price of corn. Feeds that may be substituted for corn, such as molasses or other grains, usually sell in line with their feeding value in relation to corn. As prices of grain are higher and those of

Figure 1.- Prices of oil meal and grain when it is profitable and unprofitable to feed urea



Probably profitable to substitute urea for oil meal when prices of grain and oil meal meet above the shaded area

Jan.-June 1952 U. S. Average price of soybean meal

Jan. June 1952 U. S. Average price of corn

Probably unprofitable to substitute urea for oil meal when prices of grain and oil meal meet below the shaded area

To see whether the price relation of urea and oil meal is such that it would probably be profitable to use urea: Find the price of oil meal in the top line and draw a line down from it. Find the price of grain per pound in the left-hand column and draw a line straight across the paper to the right. If the two lines meet to the right of the shaded area it would probably be profitable to use urea.

Table 3.- Price received per pound by farmers for feed grains and price paid for oil meals in selected States, yearly average 1937-51

Year	Illinois Price corn	 Price soybean meal	 Ratio	New York Price corn	 Price soybean meal	 Ratio	Alabama Price corn	 Price cotton-seed meal	 Ratio
	Dollars	Dollars		Dollars	Dollars		Dollars	Dollars	
1937	0.84	2.20	2.6	1.27	2.30	1.8	1.20	1.70	1.4
38	.81	1.65	2.0	1.11	1.80	1.6	1.05	1.35	1.3
39	.93	1.70	1.8	1.25	1.80	1.4	1.50	1.45	1.0
1940	1.09	1.70	1.6	1.36	1.90	1.4	1.36	1.70	1.3
41	1.32	2.10	1.6	1.62	2.10	1.3	1.46	1.90	1.3
42	1.60	2.50	1.6	1.86	2.55	1.4	2.09	2.20	1.1
43	1.89	2.70	1.4	2.34	2.80	1.2	2.73	2.50	.9
44	1.88	3.00	1.6	2.28	3.10	1.4	2.71	2.85	1.1
45	2.16	2.95	1.4	2.84	3.10	1.1	2.91	2.80	1.0
46	2.70	4.00	1.5	2.98	4.15	1.4	3.36	3.90	1.2
47	3.96	4.60	1.2	4.14	4.80	1.2	3.93	4.50	1.1
48	2.27	4.88	2.1	2.61	5.02	1.9	2.45	4.36	1.8
49	2.23	4.27	1.9	2.46	4.50	1.8	2.34	3.46	1.5
1950	2.84	4.24	1.5	3.16	4.40	1.4	2.64	3.85	1.5
51	3.12	4.54	1.5	3.39	4.70	1.4	2.95	4.30	1.5
Average	1.98	3.14	1.6	2.31	3.27	1.4	2.31	2.85	1.2

Year	Colorado Price grain sorghums	 Price cotton-seed meal	 Ratio	California Price barley	 Price cotton-seed meal	 Ratio
	Dollars	Dollars		Dollars	Dollars	
1937	0.84	2.30	2.7	1.33	2.07	1.6
38	.61	1.80	3.0	.92	1.65	1.8
39	1.00	2.00	2.0	.87	1.86	2.1
1940	.71	2.10	3.0	.83	1.81	2.2
41	.84	2.50	3.0	1.44	2.12	1.5
42	1.37	2.80	2.0	1.42	2.62	1.8
43	1.98	3.00	1.5	2.29	2.68	1.2
44	1.59	3.35	2.1	2.27	3.18	1.4
45	2.03	3.30	1.6	2.17	3.20	1.5
46	2.25	4.30	1.9	2.98	3.90	1.3
47	3.25	5.00	1.5	3.23	4.74	1.5
48	2.18	5.33	2.4	2.71	4.97	1.8
49	2.03	4.36	2.2	2.33	4.02	1.7
1950	2.14	4.37	2.0	2.54	3.96	1.6
51	2.50	5.12	2.0	3.12	4.43	1.4
Average	1.69	3.44	2.0	2.03	3.15	1.6

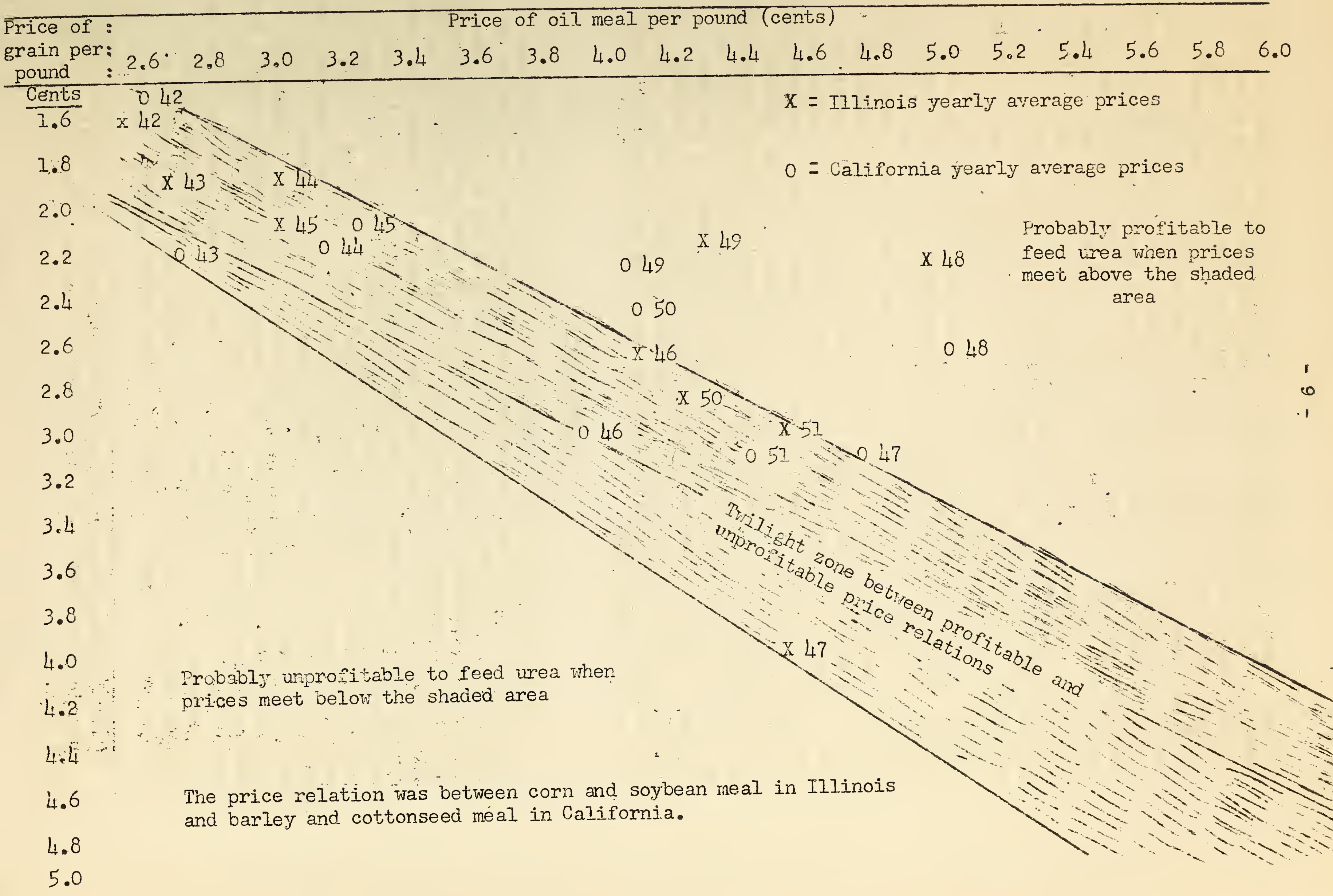


Figure 2.- Prices of oil meal and grain when it is profitable and unprofitable to feed urea and yearly average prices in California and Illinois, 1942 to 1951

The price relation was between corn and soybean meal in Illinois and barley and cottonseed meal in California.

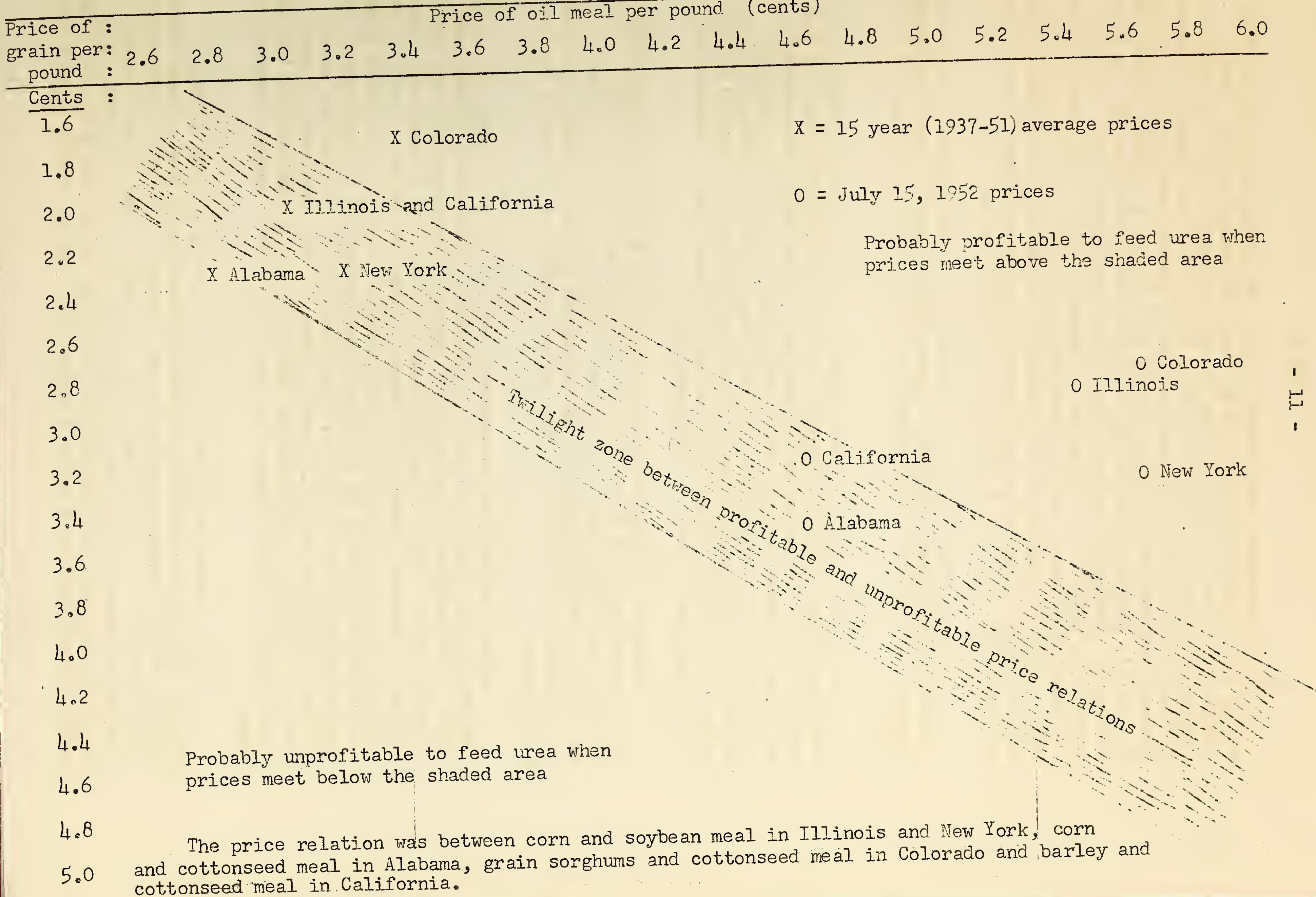
oil meal lower in the South than in most other regions, there is less opportunity there to substitute urea for cottonseed meal at a profit. In the Northeast, the price of corn is about as high as in the South. The 15-year average price of corn was 2.3 cents a pound in both New York and Alabama, and 2.5 cents a pound in Massachusetts. The price of soybean meal in New York was a little more and linseed meal a little less than in Illinois. Both were about 15 percent higher than the price of cottonseed meal in Alabama. Thus, so far as relative prices are concerned in the use of urea, the Northeast is between the Corn Belt and the South. The West Coast is in about the same position as Illinois. The yearly average price relation between grain and oil meal for Illinois and California is shown in figure 2 and table 3. It will be seen that in only 2 years of the last 10 was the price relation above the shaded zone in Illinois, and in 3 out of 4 years in California. The most advantageous place from the price standpoint for the use of urea is the area that includes the western Corn Belt and the Great Plains. Here the price of feed grains is lowest and the price of oil meals is highest. In Colorado, for instance, the 15-year average price of grain sorghums is 1.7 cents a pound and that of soybean meal 3.4 cents a pound, or twice as much. The price of grain in Colorado is thus 15 percent below that in Illinois and soybean meal is 10 percent higher. There is not a year in the last 15 when it would not have paid to substitute urea for soybean meal in Colorado, using the generally accepted formula of 1 pound of urea, plus 6 pounds of grain, as replacing 7 pounds of oil meal. Recent prices (July 1952) of oil meal in relation to grain indicate that it would be profitable to use urea in Colorado, Illinois, and New York, but not in California or Alabama (fig. 3). The long-term average price relationship, however, indicates that of the five States shown, Colorado would be the only one in which urea would be profitable.

DAIRY CATTLE

Only a few trials have been run with feeding urea to milk cows. In England, an experiment was carried on with 274 cows on 12 farms for 6 to 7 weeks. Urea was added at the 2-percent level to a ration containing 12.9 percent of protein and also to one containing 17.9 percent. In both the concentrate including the urea was fed as cubes. In the 7 weeks that the trial was run, less than a 6-percent difference was noted in yield of milk between the low- and high-protein rations with urea and less than this in the rations without urea. Urea did not significantly increase milk production in either ration. Perhaps the 12.9 percent concentrate rations, together with the hay and other roughage, was sufficient protein for these herds. Therefore, the addition of more protein, either as peanut meal or urea, did not show up in increased milk production. Recent work by the Bureau of Dairy Industry shows that cows producing around 8,000 pounds of milk, produced as much milk in each of two to three lactations, whether fed a concentrate ration of 10 to 11 percent, 14.5 to 15.5 percent, or 18.5 to 19.5 percent protein. Roughage consisted of 10 to 12 pounds timothy hay, 3 to 4 pounds of alfalfa, and 15 pounds of silage per 1,000 pounds of body weight. 4/

4/ New Ideas on Protein in Dairy Cow Rations, L. A. Moore, Division of Nutrition and Physiology, Bureau Dairy Industry, USDA, BDI Inf. 116 March 1951.

Figure 3.- Prices of oil meal and grain when it is profitable and unprofitable to feed urea and prices in selected States, average and July 1952



The price relation was between corn and soybean meal in Illinois and New York, corn and cottonseed meal in Alabama, grain sorghums and cottonseed meal in Colorado and barley and cottonseed meal in California.

A Massachusetts experiment on high producing cows (13,000 lbs.) showed that 1 pound of urea plus 4 pounds of grain replaced about 5 pounds of oil meal. Urea was fed at the 3-percent level. Roughages fed were grass hay, silage, and dried beet pulp. In Wisconsin, a comparison was made between a basal ration of grains containing 10-percent protein, the same ration with linseed meal giving a protein content of 18 percent, and the same ration with urea taking the place of the linseed meal. Roughages fed were corn silage and timothy hay. In this experiment, adding the linseed meal increased total milk production per cow from 7,855 pounds for the basal ration to 9,355 pounds, or 19 percent. The urea increased milk production 14 percent. One pound of urea plus 10 pounds of grain replaced about 11 pounds of linseed meal. Urea was fed at the level of 3 percent of the grain ration.

Until further evidence is available, it would seem that the conventional expression, "1 pound of urea plus 6 pounds of grain replaces 7 pounds of oil meal" -- will serve for dairy cows as well as for beef cattle.

Urea would seem to have a place in feeding average dairy cows producing 7,000 to 10,000 pounds of milk when farm grains are fed and when little if any legume hay is available. It should not amount to more than 3 percent of the grain ration and it should be thoroughly mixed with the ground grains. If more than 5 pounds of grain is fed per day to a high producing cow, the percentage of urea should be reduced. The English experiments showed that more than 3 ounces a day had a depressing effect on milk production.

Urea does not appear to be effective when added to concentrate milk-cow rations that already contain 14-percent protein or more. The effective percentage may be even less than this. Urea is apparently not effective when legumes are the principal roughages unless the cows are high-producing animals. This would probably apply also to cows on good pasture.

In New England, the concentrate ration for dairy cattle is mostly commercial mixed feed. The hay is typically a mixture of timothy and clover. The concentrate ration often contains 16 percent or more protein the year around. This is probably more protein than is necessary from a physical standpoint. Urea could probably take the place of much of the oilseed meal fed to milk cows in this area; however, the price of grain in relation to oil meal is as high in New England as in the South. The 15-year average price of corn in Massachusetts was 2.5 cents a pound and that of linseed meal 3.2 cents a pound. Thus, the price of meal averaged 1 1/4 times the price of corn. In only 2 years of the last 15 has the price of meal averaged as much as twice the price of corn per pound.

Table 4 shows the effect in cost of adding urea to a dairy ration. The concentrate ration shown contains about 14.5 percent protein. This is probably enough protein for the average dairy herd, even when no legumes are fed. It was assumed that 2 pounds of urea plus 12 pounds of corn in the second ration would replace the 14 pounds of soybean meal in the first ration. The cost of each ration is shown with grain at 2 1/2 cents a pound, urea at 6 cents a pound, and soybean meal at prices that

Table 4.- Difference in cost of dairy ration (concentrate) with soybean meal and with urea at different relative prices of grain and oil meal

Dairy ration (14.5% protein)			Cost of ration when grain (corn, oats, and bran) is 2½ cents a pound and the price of soybean meal is:									
			2.5 cents		3 cents		3½ cents		4 cents		6 cents	
			Ration		Ration		Ration		Ration		Ration	
	With soybean meal	With urea	Oil meal	Urea	Oil meal	Urea	Oil meal	Urea	Oil meal	Urea	Oil meal	Urea
	Pounds	Pounds										
Corn	50	62	2.12	2.42	2.12	2.42	2.12	2.42	2.12	2.42	2.12	2.42
Oats	25	25										
Bran	10	10										
Soybean meal	14	--	.35	--	.42	--	.49	--	.56	--	.84	--
Salt	1	1	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Urea		2	--	.12	--	.12	--	.12	--	.12	--	.12
Total	100	100										
Cost of ration per 100 lbs.			2.49	2.56	2.56	2.56	2.63	2.56	2.70	2.56	2.98	2.56
Cost of ration containing urea compared with ration containing soybean meal			103 %		100 %		97 %		95 %		86 %	
Relative price of oil meal to grain per pound			1.0		1.2		1.4		1.6		2.4	

range from 2 1/2 to 6 cents a pound. It shows that the price of oil meal must be more than 1 1/4 times the price of grain if the substitution of urea is to be profitable and that even when oil meal is 4 cents a pound, or 1.6 times the price of grain, the saving is only 5 percent in the cost of ingredients in the grain ration. In New York, in only 3 years in 15 was the price of soybean meal 1 3/4 times that of corn and in none was the price twice that of corn. The savings to be had from the use of urea in replacing oil meal in dairy rations are therefore rather limited in New York and even more so in New England. This is true also in the South where the price ratio between cottonseed meal and corn has exceeded 1.6 in only 1 year in the last 15. In Illinois, 3 years the soybean meal-corn ratio was 2 or more and in 7 years it was between 1.5 and 2. The situation in California is similar to that in Illinois, using barley and cottonseed meal as the feeds compared. In Colorado, however, in no year was the price ratio of cottonseed meal to grain sorghums less than 1 1/2. In 11 years it was 2.0 or more. The area in which urea has the greatest economic advantage lies in the Great Plains and western Corn Belt where the widest spread normally exists between the price of oil meals and grain. The savings to be expected are perhaps too small for individual dairymen to change their practices. However, manufacturers of mixed feed could well consider a dairy feed containing urea as the source of nitrogen.

When legume hay is not available, the principal advantage of urea and oil meal in the dairy ration is to raise the protein content of a straight grain ration from 10 to at least 14 percent and thus to increase the milk production per cow. In the Wisconsin experiment, the increase was 14 percent when urea was used and 19 percent when linseed meal was used, as compared with a straight grain ration. In this experiment in which average prices for feeds and milk were used, 1 pound of urea was worth 38 cents and 1 pound of linseed meal about 6.2 cents. This comparison was for a ration containing no legume hay and no protein concentrate. However, in the long run, the cheapest way to have enough protein in the ration is to have good legume hay.

From an economic standpoint, the experiments upon which the tentative conclusions are based are too few and have too great a variation in results to be entirely conclusive. More research work on feeding urea to both beef cattle and milk cows, especially in regions where urea appears to have the greatest economic advantages, would help to sharpen the answers on questions of costs and returns.

In addition to its use as a substitute for oil meal, urea can also be thought of as an extender of the feed supply. It will permit greater utilization of such feeds as corncobs, straw, and stover, which at present contribute little in the way of feed. Urea can thus increase the total quantity of animal products available for human food.